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Alternative approaches to the velocity of climate change: assessment against observations

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Climate change causes shifts in distribution ranges of species. The velocity of these shifts is often related to that of climate change, such as the poleward shift of the isotherms. However, species range shifts are not solely determined by climate parameters. Short-term meteorological values, topography, and other barriers also play a role. Moreover, the magnitude and direction of the climate velocity are not defined univocally. They depend on implicit assumptions that underlie the calculations, particularly in determining the direction of the velocity vector. The classical gradient-based definition of climate change [1] displays limitations, in particular local divergence [2], which led us to recently introduce an alternative method maximising the regularity of the velocity field, named Monte-cArlo iTerative Convergence metHod (MATCH) [3].

Since the latter stems from mathematical arguments, its relevance to ecology requires careful assess- ment. We consider North-American birds based on the Audubon Christmas Bird Count as well as marine species recorded in the North-East Atlantic region of the NOAA fisheries survey. For each species, the centroid of the distribution area is determined at two time ranges, and its shifting velocity, in magnitude and direction, is deduced. We also calculate the shift of the isotherms for ground and sea-surface tem- peratures, respectively, at each observation spot, and deduce an average shifting velocity for both the Gradient-based and the MATCH methods.

When comparing the respective shifts of the ranges of species and of climate, we only found a significant positive correlation between latitudinal shift of marine species and their climate counterpart, as calculated with the MATCH approach. Neither the classical gradient method, nor longitudinal shifts, nor bird range shifts displayed significant correlations. Our results therefore suggest that the MATCH approach may provide more ecologically relevant velocity fields. We also confirmed previous observations that marine species better track temperature evolutions than terrestrial ones. Such assessment may help anticipating species range shift and designing conservation strategies.

References

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